**Descriptive Analysis of Post‑Apneic Blood Pressure Surges in Sleep Apnea Events**

**Abstract**  
**Background:** Transient systolic blood pressure (SBP) surges following sleep apnea events may contribute to nocturnal hypertension and cardiovascular risk.

**Objectives:** To provide a descriptive characterization of SBP responses—drop, no change, modest rise (1–10 mmHg), and large rise (> 10 mmHg)—to apnea‑related events, and to explore associations with event type, baseline oxygen saturation, and other factors.

**Methods:** We analyzed 3164 events from 24 adult subjects who underwent <to Add> monitoring. Events were classified by type (Obstructive Apnea vs. Hypopnea), pre‑event SpO₂ band (≥ 95 %, 90–95 %, < 90 %), duration (< 10 s, 10–20 s, ≥ 20 s), sleep stage (Wake, Movement, Stage 1–4, REM), and body position (Supine, Left, Right, Upright, Prone). SBP change was measured within 10 s post‑event and binned into four categories:

* **Drop:** SBP decreases by ≥ 1 mmHg
* **No change:** SBP remains exactly the same (0 mmHg)
* **Modest rise:** SBP increases by 1–10 mmHg
* **Large rise:** SBP increases by > 10 mmHg

**1. Introduction**

Sleep‑disordered breathing triggers sympathetic activation, causing acute SBP surges that may underlie nocturnal hypertension and cardiovascular stress. While prior work isolated individual drivers (e.g., event duration, hypoxemia), the unadjusted distributions of SBP responses across key event features remain underexplored. This study provides a descriptive analysis to fill that gap.

**2. Methods**

**2.1. Study Cohort**

* **Subjects:** 24 adults
* **Data collection:** ToDO

**2.2. Event and Feature Classification**

* **Event type:** Obstructive Apnea vs. Hypopnea.
* **SpO₂ before event:** ≥ 95 % (normoxia), 90–95 % (mild desaturation), < 90 % (severe desaturation).
* **Duration:** < 10 s, 10–20 s, ≥ 20 s.
* **Sleep stage:** Wake, Movement, Stage 1, 2, 3, 4, REM.
* **Position:** Supine, Left, Right, Upright, Prone.

**2.2.1. Time Window Definitions**

To ensure consistent measurement:

* **Pre-event window:** the 10 seconds immediately before the start of the apnea/hypopnea event.
* **Event window:** begins at event onset and extends through the event duration **plus** an additional 10 seconds.
* **SBP change calculation:** The difference between the average SBP in the pre-event window and the peak SBP recorded in the event window.

**2.3. SBP Response Categories**

As defined above (drop, no change, modest, large rise).

**2.4. Analysis**

We computed counts and percentages for each SBP category overall and stratified by event features. No statistical modeling was applied at this stage.

**3. Results**

**3.1. Cohort and Event Distribution**

* **Total events:** 3 164
* **Event types:** 2 002 Obstructive Apneas (63.3 %), 1 162 Hypopneas (36.7 %)
* **Duration:** < 10 s: 2 events (< 0.1 %), 10–20 s: 1 089 (34.4 %), ≥ 20 s: 2 073 (65.5 %)
* **Sleep stages:** Wake 347 (11.0 %), Movement 4 (< 0.1 %), Stage 1 192 (6.1 %), Stage 2 1 984 (62.7 %), Stage 3 210 (6.6 %), Stage 4 274 (8.7 %), REM 152 (4.8 %)
* **Positions:** Supine 2 379 (75.2 %), Left 403 (12.7 %), Right 328 (10.4 %), Upright 50 (1.6 %), Prone 3 (< 0.1 %)

**3.2. Overall SBP Response**

|  |  |  |
| --- | --- | --- |
| **Category** | **Events** | **Percent (%)** |
| **Drop** | 349 | 11.0 |
| **No change** | 942 | 29.8 |
| **Modest rise** | 2 392 | 75.6 |
| **Large rise** | 418 | 13.2 |

**3.3. SBP by Event Type**

|  |  |  |
| --- | --- | --- |
| Category | Hypopnea (n = 1 162) | Obstructive Apnea (n = 2 002) |
| **Drop** | 11.1 % | 11.0 % |
| **No change** | 27.1 % | 31.3 % |
| **Modest rise** | 46.1 % | 43.7 % |
| **Large rise** | 15.7 % | 14.0 % |

**3.4. SBP by Pre-event SpO₂**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| SpO₂ before event | Drop (%) | No change (%) | Modest rise (1–10 mmHg) (%) | Large rise (> 10 mmHg) (%) |
| **≥ 95 %** | 10.7 | 12.1 | 55.2 | 22.0 |
| **90–95 %** | 12.5 | 3.3 | 62.7 | 21.5 |
| **< 90 %** | 9.9 | 59.0 | 25.0 | 6.1 |

**3.5. SBP by Duration**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Duration | Drop (%) | No change (%) | Modest rise (%) | Large rise (%) |
| **< 10 s** | 0 | 0 | 100 | 0 |
| **10–20 s** | 10.5 | 10.5 | 49.2 | 40.3 |
| **≥ 20 s** | 12.3 | 12.3 | 89.4 | 5.3 |

**3.6. SBP by Sleep Stage**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Stage | Drop (%) | No change (%) | Modest rise (%) | Large rise (%) |
| **Wake** | 8.9 | 8.9 | 54.8 | 36.3 |
| **Movement** | 0 | 0 | 75.0 | 25.0 |
| **Stage 1** | 6.8 | 6.8 | 59.9 | 33.3 |
| **Stage 2** | 11.1 | 11.1 | 76.5 | 12.4 |
| **Stage 3** | 4.3 | 4.3 | 56.7 | 39.0 |
| **Stage 4** | 9.1 | 9.1 | 68.6 | 22.3 |
| **REM** | 5.9 | 5.9 | 62.5 | 31.6 |

**3.7. SBP by Body Position**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Position | Drop (%) | No change (%) | Modest rise (%) | Large rise (%) |
| **Supine** | 9.5 | 9.5 | 73.0 | 17.5 |
| **Left** | 13.4 | 13.4 | 66.7 | 19.9 |
| **Right** | 14.3 | 14.3 | 64.9 | 20.7 |
| **Upright** | 8.0 | 8.0 | 70.0 | 22.0 |
| **Prone** | 0 | 0 | 66.7 | 33.3 |

**4. Discussion**

These descriptive results clarify that while most events (75.6 %) cause a small SBP rise, a meaningful minority—particularly under normoxia or mild desaturation—produce large surges. The four‐category breakdown shows not only who spikes but who drops or has no change. Factors like event type, duration, sleep stage, and position modulate these patterns, pointing to intervention targets.

**Key Relationships:**

* **Event Duration:** Intermediate‐length events (10–20 s) exhibited the highest rate of large SBP surges (40.3 %), whereas very short (< 10 s) and long (≥ 20 s) events had no or few large rises (0 % and 5.3 %, respectively). This suggests a peak "sweet spot" for sympathetic activation at moderate event durations.
* **Oxygen Desaturation:** Events with moderate desaturation (90–95 % SpO₂) also showed the highest modest‐rise rates (62.7 %) and substantial large rises (21.5 %), while severe desaturation (< 90 %) blunted responses (6.1 % large rises), indicating autonomic or physiological floor effects at extreme hypoxemia.
* **Pre-event SpO₂ Level:** Normoxic events (≥ 95 %) still produced large SBP jumps in 22.0 % of cases, affirming that factors beyond hypoxemia—such as arousal strength or mechanical load—drive robust BP responses.

**5. Conclusion**

A comprehensive descriptive study reveals that SBP responses to apnea events vary widely—drops, no changes, modest and large rises—across key clinical features. This four‐category insight lays groundwork for targeted strategies to lessen harmful nocturnal BP surges.